Backgrounder

United States Nuclear Regulatory Commission
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Dry Cask Storage of Spent Nuclear Fuel

Background

For years, nuclear power plants have temporarily stored used fuel, known as "spent fuel," in water pools at the reactor site. Periodically, about one-third of the nuclear fuel in an operating reactor needs to be unloaded and replaced with fresh fuel. Designers of nuclear power plants anticipated that the spent fuel would be reprocessed, with usable portions of the fuel to be recycled and the rest to be disposed as waste. Therefore, spent fuel pools were not designed with the intent to hold all the spent fuel expected over a reactor's lifetime. However, commercial reprocessing was never successfully developed in the United States.

Congress gave the Department of Energy (DOE) responsibility for developing permanent disposal capacity for the spent fuel and other high-level nuclear waste, and in 2002 Congress and the President designated Yucca Mountain, Nevada, as the site for a proposed disposal facility. The disposal facility would be built and operated by DOE and licensed by the Nuclear Regulatory Commission (NRC). The NRC is an independent regulatory agency, not a part of the DOE, whose primary mission is to protect public health and safety, the common defense and security, and the environment in the use of nuclear materials.

Until a repository is available, spent nuclear fuel continues to be stored primarily in specially designed, water-filled pools at individual reactor sites around the country. This storage is authorized under the same license issued by NRC that authorizes reactor operation.

In the late 1970s and early 1980s, the need for alternative storage began to grow when pools at many nuclear reactors began to fill up with stored spent fuel. Utilities began looking at options for increasing spent fuel storage capacity. Current regulations permit reracking (placing fuel rod assemblies closer together in spent fuel pools) and fuel rod consolidation, subject to NRC review and approval, to increase the amount of spent fuel that can be stored in the pool. Both of these methods are constrained by the size of the pool.

Another option for increasing capacity is storage in an independent spent fuel storage installation (ISFSI). Such storage may be either at the reactor site or elsewhere. The spent fuel may be stored in wet or dry ISFSIs. Over the last decade, there has been increased interest in dry cask storage on-site by licensees to provide additional capacity for storing spent fuel.

There are two ways an ISFSI may be licensed. A "site-specific license" authorizes operation of a storage facility at a nuclear power plant or elsewhere, subject to the NRC's standard licensing requirements. The license specifies the type of storage system to be used. Alternatively, nuclear power plant operators may operate an ISFSI under a "general license" using NRC-approved dry storage casks. The general license option allows plants to avoid repeating certain evaluations (such as environmental impact or seismic reviews) that were already conducted for the plant's operating license.

In 1982, Congress passed the Nuclear Waste Policy Act, which directed the NRC to approve a means of interim dry storage by rulemaking, omitting site-specific evaluations "to the maximum extent practicable." The NRC amended its regulations in 1990 to authorize nuclear power plant licensees to store spent fuel at reactor sites in NRC-approved dry storage casks under a general license, without needing to submit an application for a specific license to store spent fuel at a particular site.

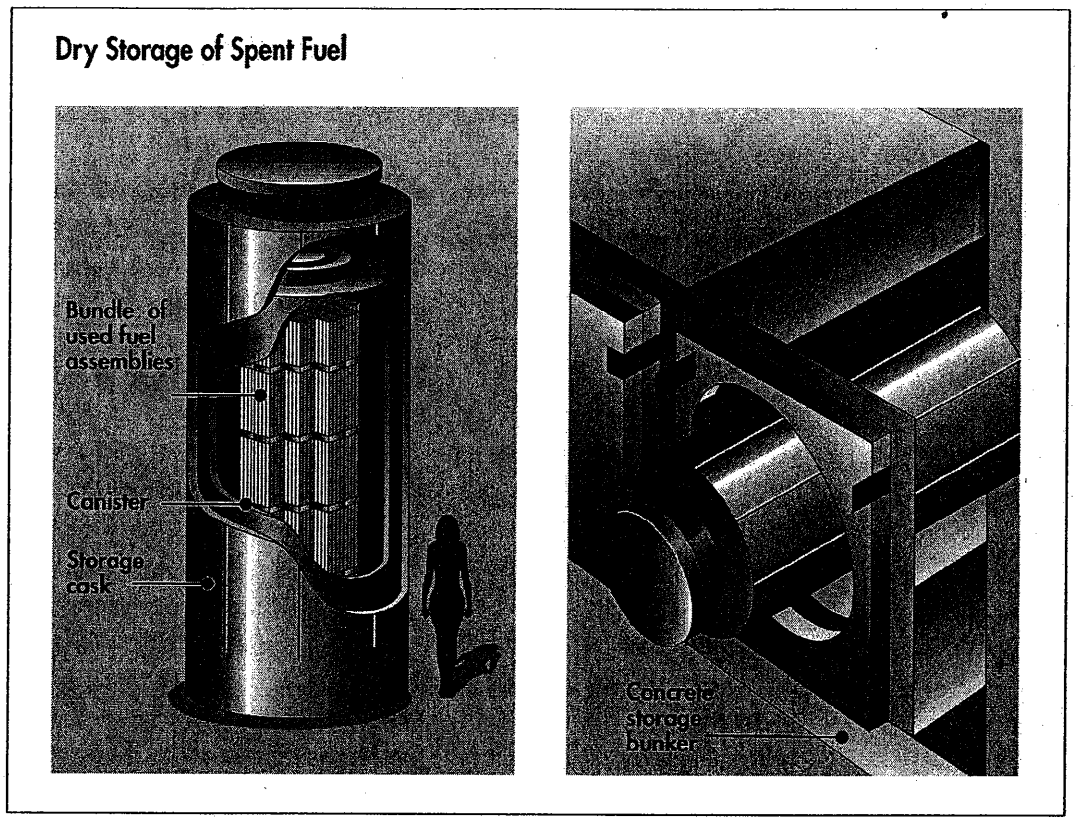
Discussion

The NRC reviews and approves the designs for spent fuel dry storage systems. The NRC's regulations for review are developed through a public process and provide a sound basis for determining whether use of a proposed storage system will protect public health and safety and the environment.

The NRC periodically inspects the design, fabrication, and the use of dry casks, to ensure licensees and vendors are performing activities in accordance with radiation safety and security requirements, and licensing and quality assurance program commitments.

Dry spent fuel storage in casks is considered to be safe and environmentally sound. Over the last 20 years, there have been no radiation releases which have affected the public, no radioactive contamination, and no known or suspected attempts to sabotage spent fuel casks or ISFSIs.

Cask designs approved for use under the general license are listed in the Commission's regulations in Title 10 of the Code of Federal Regulations under Part 72.214 and in the table at the end of this Fact Sheet. Casks typically consist of a sealed metal cylinder containing the spent fuel enclosed within a metal or concrete outer shell. In some designs, casks are placed horizontally; in others, they are set vertically on a concrete pad.



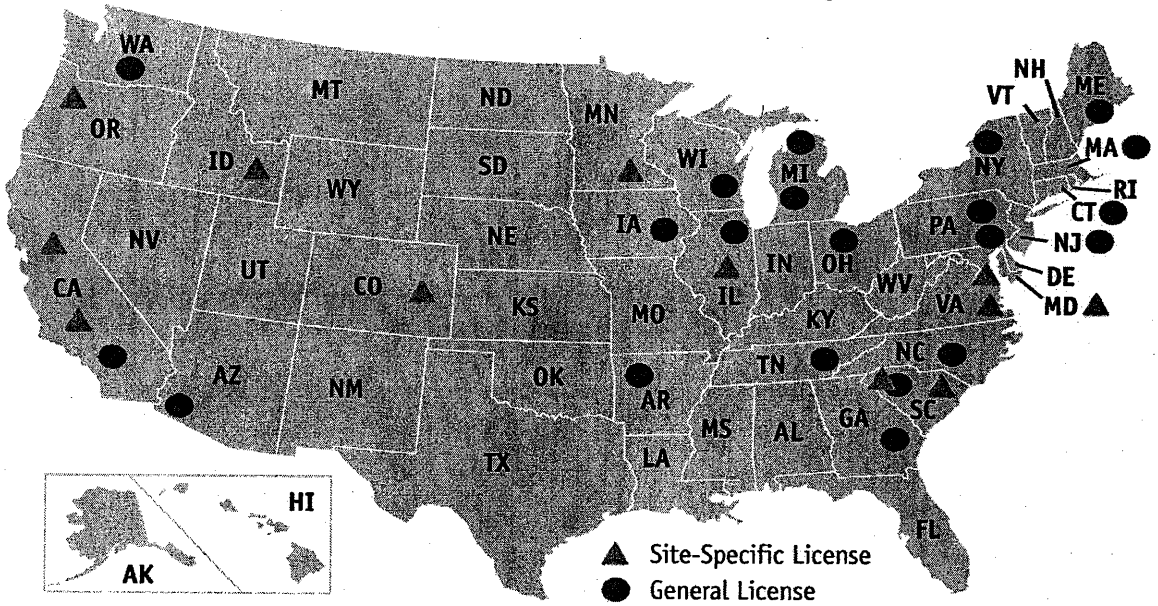
For approval of cask designs, the NRC conducts a technical review to ensure the design would be safe and secure for use at any licensed nuclear power plant site in the country, consistent with the requirements for a general license. [Additional information available at www.nrc.gov/waste/spent-fuel-storage .]

The casks used in the dry storage systems are designed to resist floods, tornadoes, projectiles, temperature extremes, and other unusual scenarios. NRC requires the spent fuel to be cooled in the spent fuel pool for several years before being transferred to dry casks. Typically, the maximum heat generated from 24 fuel assemblies stored in a cask is less than that given off by a typical home heating system in an hour. As the fuel cools further, the heat generated will decrease over time.

Spent fuel is currently kept in dry storage at ISFSIs located at 25 power plants, one decommissioned power plant site (Fort St. Vrain), six plants in the process of decommissioning (Rancho Seco, Trojan, Maine Yankee, Haddam Neck, Yankee Rowe, and Big Rock Point) and at two interim storage facilities located at the Idaho National Engineering and Environmental Laboratory near Idaho Falls, Idaho. One additional ISFSI, the General Electric-Morris Operation

in Illinois, is licensed for wet storage of spent fuel. The sites employing dry cask storage are noted in the table at the end of this Backgrounder.

Licensed/Operating Independent Spent Fuel Storage Installations



ARIZONA
- ● Palo Verde

ARKANSAS
- ● Arkansas Nuclear

CALIFORNIA
- ▲ Diablo Canyon
- ▲ Rancho Seco
- ● San Onofre

COLORADO
- ▲ Fort St. Vrain

CONNECTICUT
- ● Haddam Neck

GEORGIA
- ● Hatch

IDAHO
- ▲ DOE: TMI-2 Fuel Debris
- ▲ DOE: Foster Wheeler

ILLINOIS
- ▲ GE Morris
- ● Dresden

IOWA
- ● Duane Arnold

MAINE
- ● Maine Yankee

MARYLAND
- ▲ Calvert Cliffs

MASSACHUSETTS
- ● Yankee Rowe

MICHIGAN
- ● Big Rock Point
- ● Palisades

MINNESOTA
- ▲ Prairie Island

NEW JERSEY
- ● Oyster Creek

NEW YORK
- ● James A. FitzPatrick

NORTH CAROLINA
- ● McGuire

OHIO
- ● Davis-Besse

OREGON
- ▲ Trojan

PENNSYLVANIA
- ● Susquehanna
- ● Peach Bottom

SOUTH CAROLINA
- ●▲ Oconee
- ▲ H.B. Robinson

TENNESSEE
- ● Sequoyah

VIRGINIA
- ▲ Surry
- ▲ North Anna

WASHINGTON
- ● Columbia Generating Station

WISCONSIN
- ● Point Beach

Data as of December 2004
Source: Nuclear Regulatory Commission

The NRC recently issued a license to the Foster Wheeler Environmental Corp. to construct and operate an away-from-reactor independent spent fuel storage installation at the Idaho National Engineering and Environmental Laboratory near Idaho Fall, Idaho. This facility will store spent fuel for the Department of Energy. In addition, Private Fuel Storage, LLC (PFS), has submitted an application that proposes to build a privately-owned independent spent fuel storage facility to be located on the reservation of the Skull Valley Band of Goshute Indians in Utah.

NRC-Approved Dry Spent Fuel Storage Designs Currently in Use

Model (Storage Design)	**Vendor**	**Date Approved (+ = for use under general license)**	**Facilities Where Used (* = specific license)**
CASTOR V/21 & X133 (Vertical Metal Cask)	General Nuclear Systems, Inc.	7/2/1986 8/17/1990+	Surry* (VA)
Fuel Solutions (Vertical Metal/ Concrete Cask)	BFNL Fuel Solutions	2/15/2001+	Big Rock Point (MI)
HI-STAR 100 (Vertical Metal Cask)	Holtec International	10/4/1999+	Hatch (GA) Dresden (IL)
HI-STORM 100 (Vertical Metal/ Concrete Cask)	Holtec International	3/31/1999 5/31/2000+	Trojan* (OR) Hatch (GA) Dresden (IL) Columbia (WA) FitzPatrick (NY) Arkansas Nuclear One (AR)
HI-STORM 100 S	Holtec International	7/15/2002	Farley (AL) Sequoyah (TN)
NAC-I28 (Vertical Metal Cask)	NAC International	2/1/1990	Surry* (VA)

Model (Storage Design)	**Vendor**	**Date Approved (+ = for use under general license)**	**Facilities Where Used (* = specific license)**
NAC-UMS (Vertical Metal / Concrete Cask)	NAC International	11/20/2000+	Maine Yankee (ME) Palo Verde (AZ)
NAC-MPC (Vertical Metal / Concrete Cask)	NAC International	4/10/2000+	Yankee Rowe (MA) Haddam Neck (CT)
Advanced NUHOMS-24 (Horizontal Concrete Module)	Transnuclear, Inc.	02/05/2003+	San Onofre (CA)
NUHOMS (Horizontal Concrete Module)	Transnuclear, Inc.	8/13/1986 1/29/1990 11/25/1992 6/30/2000 1/18/1995+	H.B. Robinson* (SC) Oconee* (SC) Calvert Cliffs* (MD) Rancho Seco* (CA) Davis-Besse (OH) Susquehanna (PA) Duane Arnold (IA) Oyster Creek (NJ) Palisades (MI) Point Beach (WI)
TN-32 (Vertical Metal Cask)	Transnuclear, Inc.	7/2/1986 6/30/1998 4/19/2000+	Surry* (VA) North Anna* (VA) McGuire (NC) Peach Bottom (PA)
TN-40 (Vertical Metal Cask)	Transnuclear, Inc.	10/19/1993	Prairie Island* (MN)
TN-68 (Vertical Metal Cask)	Transnuclear, Inc.	5/28/2000+	McGuire (NC) Peach Bottom (PA)

Southern Nuclear Operating Co.	Farley 1&2	September 2003			
Entergy Operations	Arkansas Nuclear One 2	October 2003			
Indiana & Michigan Power Co.	Cook 1&2	November 2003			
Tennessee Valley Authority	Browns Ferry 1, 2 &3	January 2004			
Dominion Nuclear Connecticut, Inc.	Millstone 2&3	January 2004			
Nuclear Management Co.	Point Beach 1 & 2	February 2004			
Constellation Energy	Nine Mile Point 1 & 2	May 2004			

* Plant-specific supplement to the Generic Environmental Impact Statement
** Safety Evaluation Report

Other licensees have expressed interest in license renewal and have described their plans to submit license renewal applications. In anticipation of an increasing number of renewal applications in the coming years, and with increasing experience in reviewing license renewal applications, the NRC expects to make the renewal review process more efficient.

The status of pending planned applications as well as additional information on license renewal can be found at: http://www.nrc.gov/reactors/operating/licensing/renewal.html on the NRC web site.

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Fact Sheet
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Reactor License Renewal

Introduction

Based on the Atomic Energy Act, the Nuclear Regulatory Commission (NRC) issues licenses for commercial power reactors to operate for up to 40 years and allows these licenses to be renewed for another 20 years. A 40-year license term was selected on the basis of economic and antitrust considerations--not technical limitations.

The first 40-year operating licenses will expire for three plants in the year 2009. Of the 100 remaining operating plants, 23 will have their licenses expire by the year 2015. The decision whether to seek license renewal rests entirely with nuclear power plant owners, and typically is based on the plant's economic situation and whether it can meet NRC requirements.

The NRC has established a license renewal process that can be completed in a reasonable period of time with clear requirements to assure safe plant operation for up to an additional 20 years of plant life.

Background

In 1982, based on a widely attended workshop on nuclear power plant aging, the NRC established a comprehensive program for Nuclear Plant Aging Research. Based on the results of that research, a technical review group concluded that many aging phenomena are readily manageable and do not pose technical issues that would preclude life extension for nuclear power plants.

In 1991, the NRC published safety requirements for license renewal as 10 CFR Part 54 (Title 10 of the Code of Federal Regulations, Part 54). The NRC then undertook a demonstration program to apply the rule to pilot plants and develop experience to establish implementation guidance. To establish a scope of review, the rule defined age-related degradation unique to license renewal. However, during the demonstration program, the NRC found that many aging effects are dealt with adequately during the initial license period. In addition, the NRC found that the review did not allow sufficient credit for existing programs, particularly those under NRC's maintenance rule, which also helps manage plant aging phenomena.

As a result, in 1995, the NRC amended the license renewal rule. The amended Part 54 established a regulatory process that is more efficient, more stable and more predictable than the previous license renewal rule. In particular, Part 54 was clarified to focus on managing the adverse effects of aging. The rule changes were intended to ensure that important systems,

structures and components will continue to perform their intended function during the 20-year period of extended operation.

NRC's responsibilities under the National Environmental Policy Act call for a review of the environmental impact of license renewal. In parallel with aging efforts, the NRC pursued a separate rulemaking, 10 CFR Part 51, to focus the scope of review of environmental issues.

Renewal Process

The license renewal process proceeds along two tracks -- one for review of safety issues (Part 54) and another for environmental issues (Part 51). An applicant must provide NRC an evaluation that addresses the technical aspects of plant aging and describes the ways those effects will be managed. It must also prepare an evaluation of the potential impact on the environment if the plant operates for another 20 years. The NRC reviews the application and verifies the safety evaluations through inspections.

Public participation is an important part of the license renewal process. There are several opportunities for members of the public to question how aging will be managed during the period of extended operation. Information provided by the licensee is made available to the public in a variety of ways. Shortly after the NRC receives a renewal application, a public meeting is normally held near the nuclear power plant to provide the public information about the license renewal process and opportunities for public involvement. Additional public meetings are held by the NRC during the review of the renewal application, and NRC evaluations, findings and recommendations are published when completed.

All public meetings are posted on NRC's web site, with key ones being announced in press releases and in the *Federal Register*. Concerns may be litigated in an adjudicatory hearing if any party that would be adversely affected requests a hearing. In addition, members of the public may petition the Commission for consideration of issues other than the management of the effects of aging during the period of extended operation of the plant.

A nuclear power plant licensee may apply to the NRC to renew its license as early as 20 years before expiration of its current license. There is no limit on how late a licensee may apply for license renewal. However, if the licensee submits a renewal application that is sufficient for the NRC's review at least five years before expiration of its current license and the agency is still reviewing the application at the end of the five years, the plant can continue to operate until the NRC completes its review. If a sufficient application is not submitted at least five years before and the current license expires before the review has been completed, the plant may have to cease operations until the renewal decision is made.

License renewal is expected to take about 30 months, including the time to conduct an adjudicatory hearing, if necessary, or 22 months without a hearing (25 months prior to 2003). Upon receipt of a license renewal application, the review is conducted, in general, according to the steps in the following table:

Licensing Milestone	Months Elapsed
Receive renewal application	0
Conduct public meeting on license renewal process	1.0
Publish notice of opportunity for hearing	1.5
Opportunity for hearing closes	3.5
Conduct public meeting on scope of environmental impact statement	4.0
Pose environmental questions to applicant	5.5
Pose safety questions to applicant	7.5
Issue draft environmental impact statement for comment	11.0
Conduct public meeting on draft environmental impact statement	12.5
Issue safety evaluation; identify open items	14.0
Receive responses to open items from applicant	16.0
Issue final environmental impact statement	18.0
Issue safety evaluation supplement	19.0
Complete Advisory Committee on Reactor Safety Review	20.5
Make decision on application (without hearing)	22.0
Complete hearing process (if needed)	---
Make decision on application (with hearing)	30.0

Environmental Reviews

Environmental protection regulations were revised in December 1996, to facilitate the environmental review for license renewal. Certain issues are evaluated generically for all plants, rather than separately in each plant's renewal application. The generic evaluation, NUREG-1437, "Generic Environmental Impact Statement for License Renewal of Nuclear Plants" (GEIS), assesses the scope and impact of environmental effects that would be associated with license renewal at any nuclear power plant site such as endangered species, impacts of cooling water systems on fish and shellfish, and ground water quality. A plant-specific supplement to the generic environmental impact statement is required for each application for license renewal.

The NRC performs plant-specific reviews of the environmental impacts of license renewal in accordance with the National Environmental Policy Act (NEPA) and the requirements of 10 CFR Part 51. A public meeting is held near the nuclear power plant seeking renewal to "scope out" or identify environmental issues specific to the plant for the license renewal action. The result is an NRC recommendation on whether the environmental impacts are so great that they preclude license renewal. This recommendation is presented in a draft plant-specific supplement to the GEIS which is published for comment and discussed at a separate public meeting. After consideration of comments on the draft, NRC prepares and publishes a final plant-specific supplement to the GEIS.

In March 2000, NRC issued a standard review plan (NUREG-1555, Supplement No.1) providing guidance on how the agency is to review the environmental portions of renewal applications. In September 2000, NRC issued Supplement 1 to Regulatory Guide 4.2, identifying the format and content of environmental reports which must accompany license renewal applications.

Safety Reviews

License renewal requirements for power reactors are based on two key principles:

> 1) Operating plants will continue to maintain adequate levels of safety during the plant's life under requirements of their original licenses. A possible exception may be the detrimental effects of aging on certain systems, structures and components, and possibly a few other issues that arise only during the period of extended operation, and
>
> 2) Each plant's licensing basis is required to be maintained during the renewal term. An applicant is required to identify all plant systems, structures and components that are safety-related, or whose failure could affect safety-related functions, and that are relied on to demonstrate compliance with the NRC's regulations for fire protection, environmental qualification, pressurized thermal shock, anticipated transients without scram, and station blackout.

An applicant must review all systems, structures and components within the scope of the rule to identify "passive" and "long-lived" structures and components. It must be demonstrated that the effects of aging will be managed in such a way that the intended functions of those structures and components will be maintained for the period of extended operation. Passive and long-lived structures and components include components such as the reactor vessel, reactor coolant system piping, steam generators, pressurizer, pump casings, and valve bodies.

The detrimental aging effects in "active" components are more readily detected and corrected by routine surveillance, performance indicators and maintenance. Surveillance and maintenance programs for active components are required throughout the period of extended operation. Active components include equipment such as motors, diesel generators, cooling fans, batteries, relays, and switches.

For some passive structures and components within the scope of the renewal evaluation, no additional action may be required where an applicant can demonstrate that the existing programs provide adequate aging management throughout the period of extended operation. However, if additional aging management activities are warranted for a structure or component within the scope of the rule,

applicants will have the flexibility to determine appropriate actions. These activities could include, for example, adding new monitoring programs or increasing inspections.

Another requirement for license renewal is the identification and updating of time-limited aging analyses. During the design phase for a plant, certain assumptions about the length of time the plant will be operated are made and incorporated into design calculations for several of the plant's systems, structures, and components. Under a renewed license, these calculations must be shown to be valid for the period of extended operation.

The NRC developed guidance for implementation of the license renewal rule with input from interested stakeholders. A Generic Aging Lessons Learned (GALL) report (NUREG-1801) was prepared and made publicly available. The report documents the basis for determining when existing programs are adequate and when existing programs should be augmented for license renewal. The GALL report is referenced in the standard review plan for license renewal (NUREG-1800) as the basis for identifying those programs that warrant particular attention during NRC's review of a license renewal application.

The NRC also issued Regulatory Guide 1.188 which provides the format and content of the safety aspects of a license renewal application. It endorses a guideline prepared by the Nuclear Energy Institute as an acceptable method of implementing the license renewal rule. The NRC will continue to include changes to the guide and the standard review plan as generic renewal issues are resolved, as well as other changes resulting from lessons learned and process improvements identified during the review of renewal applications.

Inspections

The NRC has established an inspection program for license renewal that verifies the information in the application and NRC's evaluation. The inspections sample the results of the process used by the licensee to identify those structures and components within the scope of license renewal, aging management programs and design analysis changes. The NRC conducts two inspections and may conduct a third, if needed.

Hearings

The Commission expects that hearings be conducted on an efficient and reliable schedule, while ensuring fair resolution of contested issues. In addition, there should be timely identification of any open generic policy issues for Commission decision and effective integration of the review of technical issues into the adjudicatory process.

The Commission amended its regulations concerning its rules of practice to make the NRC's hearing process more effective and efficient (*Federal Register* Vol. 69, page 2182, January 14, 2004). Hearing procedures are tailored to the differing types of licensing and regulatory activities the NRC conducts and will better focus limited resources of involved parties and the NRC. The new regulations became effective on February 13, 2004.

Industry Activities

The industry has submitted technical reports on particular license renewal topics for NRC approval. This approach, along with compilations of past aging research programs, established a foundation of technical information that licensees can use to evaluate the feasibility of license renewal and later reference in a license renewal application.

With regard to pressurized water reactors, the Babcock & Wilcox Owners Group, representing five operating B&W plants, has formulated a generic license renewal program. The B&W Owners Group has submitted generic license renewal reports on the reactor coolant system piping, the pressurizer, the reactor pressure vessel, and reactor vessel internals. The Westinghouse Owners Group also has a program for license renewal and has submitted technical reports on the aging management activities for the reactor coolant system supports, the pressurizer, certain piping, the containment structure, and the reactor vessel internals. The Boiling Water Reactor Owners Group has concentrated its efforts on reports related to the reactor vessel internals program.

Industry representatives participated in working groups and technical committees, coordinated by the Nuclear Energy Institute, to address generic technical and process issues. The resolution of the generic renewal issues and lessons learned during the review of renewal applications are documented and will be included in future revisions of the guidance documents for implementing the license renewal rule. Development of improved guidance is expected to improve the efficiency of future renewal reviews.

Status of License Renewal Applications

See the table below for the status of license renewal applications.

Status of License Renewal Applications

Applicant	Plant Name & Units	Date Application Received by NRC	Date NRC Issued GEIS Supplement*	Date NRC Issued SER**	Date NRC Issued License
Baltimore Gas & Electric Co.	Calvert Cliffs 1 & 2	April 1998	November 1999	November 1999	March 2000
Duke Energy	Oconee 1, 2, & 3	July 1998	February 2000	February 2000	May 2000
Entergy Operations	Arkansas Nucl. One 1	February 2000	April 2001	April 2001	June 2001
Southern Nuclear Operating Co. Inc.	Edwin I. Hatch 1 & 2	March 2000	May 2001	October 2001	January 2002
Florida Power & Light Co.	Turkey Point 3 & 4	September 2000	January 2002	February 2002	June 2002
Virginia Electric & Power	Surry 1 & 2 North Anna 1 & 2	May 2001	December 2002	November 2002	March 2003
Duke Energy	McGuire 1&2 Catawba 1 & 2	June 2001	December 2002	January 2003	December 2003
Exelon	Peach Bottom 2&3	July 2001	January 2003	February 2003	May 2003
Florida Power & Light Co.	St. Lucie 1 & 2	November 2001	May 2003	July 2003	October 2003
Omaha Public Power District	Fort Calhoun	January 2002	August 2003	September 2003	November 2003
Carolina Pwr. & Light	Robinson 2	June 2002	December 2003	January 2004	April 2004
Rochester Gas & Elec. Corp.	Ginna	August 2002	January 2004	March 2004	May 2004
SCE&G	Summer	August 2002	February 2004	January 2004	April 2004
Exelon	Dresden 2 & 3 Quad Cities 1 & 2	January 2003	June 2004	July 2004	

Model (Storage Design)	Vendor	Date Approved (+ = for use under general license)	Facilities Where Used (* = specific license)
VSC-24 (Vertical Metal/ Concrete Cask)	BNFL Fuel Solutions Corp.	5/7/1993	Palisades (MI) Point Beach (WI) Arkansas Nuclear One (AR)
NAC S/T	NAC International	8/17/1990	Not being used at this time
NAC-C28 S/T	NAC International	8/17/1990	Not being used at this time

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